Installation of ANNIE Front Veto
17 July 2015

Description of Work: Install 26 plastic scintillator paddles on the front face of the ANNIE experimental Hall. The paddles have an active area of 10' 6" by 1' 1/8" and are single-ended readout via a light guide and single 2" photomultiplier tube (PMT). The light guide and PMT add an additional length of 2' 2 ¼". Thickness of the paddle is 7/8". Each paddle weighs about 30 kg. Mounting will require bolting vertical aluminum struts to a concrete wall from the floor to a height of 13'. Paddles will then be mounted in pairs to these rails and retained by additional aluminum strut. During assembly, high voltage and signal cables will be attached and run to an electronics rack on the second level. Before assembly, one electrical conduit may be moved from floor level to a height of about 15' to avoid interference with the vertical rails. In addition, after each layer is installed it will be tested for operation by powering up the paddle and observing dark noise rates and pulse heights. If required, minor troubleshooting may be required to fix any light leaks or faulty cables or connectors.

Hazard Analysis: Potential Hazards for this work are:

1. Hazards associated with going up and down the ANNIE Hall stairs
2. Above the 5th horizontal layer work will need to be done from scaffolds or ladders. Top layer is at 13'
3. Hazards associated with high voltage
4. Hazards associated with lifting 30 kg

Description of Veto: Figure 1 shows a drawing of the paddles mounted in 2 stacks, each 13 paddles high. This height is needed to completely cover the target tank. This is the configuration desired for ANNIE. The desired location in the hall is shown in Figure 2. The veto must fit in front of the target tank to be effective. Space limitation is that there is 10" 4" of clearance between the front wall of the hall and the Muon Range Detector (MRD) and this must accommodate a 9' diameter tank. Therefore the veto must fit into a space less than 1' in width.

Since the paddles have a muon detection efficiency that falls from about 90% near the light guide to 50% or so at the far end, the paddles are in two horizontal layers with PMT readout on opposite sides. This increases efficiency and also makes the coverage more even. In addition, a small gap is avoided between the horizontal layers by slightly offsetting the paddle heights in the mounting design.

The basic mounting structure will be made using extruded aluminum strut (15 series Faztek). See Figure 4. This strut has a yield strength of 25,000 psi, which is well below the expected load of 500 lbs per vertical rail (this includes weight of strut and paddles). Figure 1 shows drawings of the bolt-together structure. The vertical rails must be in two pieces since the largest commercial length sold is 96". The outer retaining struts are in sections to allow dropping in paddles in 3 horizontal layers at a time. The paddles rest on custom shaped aluminum slats bolted to the struts (see figure 3). Each rail has one slat, so each slat must support only 30 lbs.

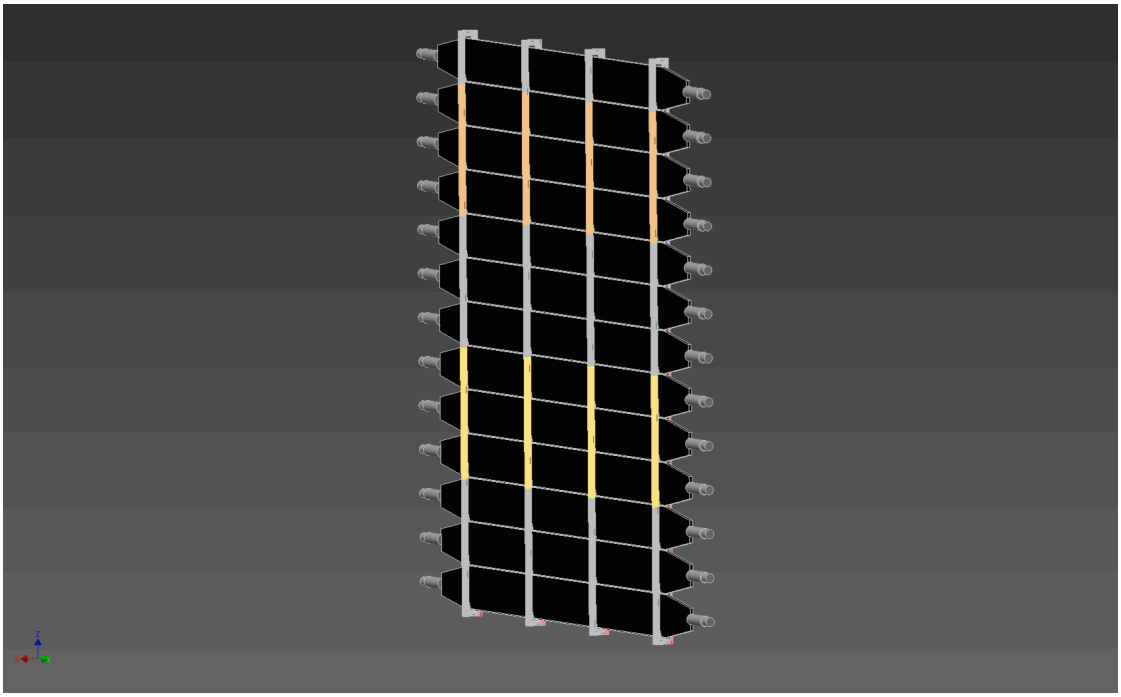

Figure 1 A front view of the ANNIE Front Veto stack showing the 13 horizontal layers.

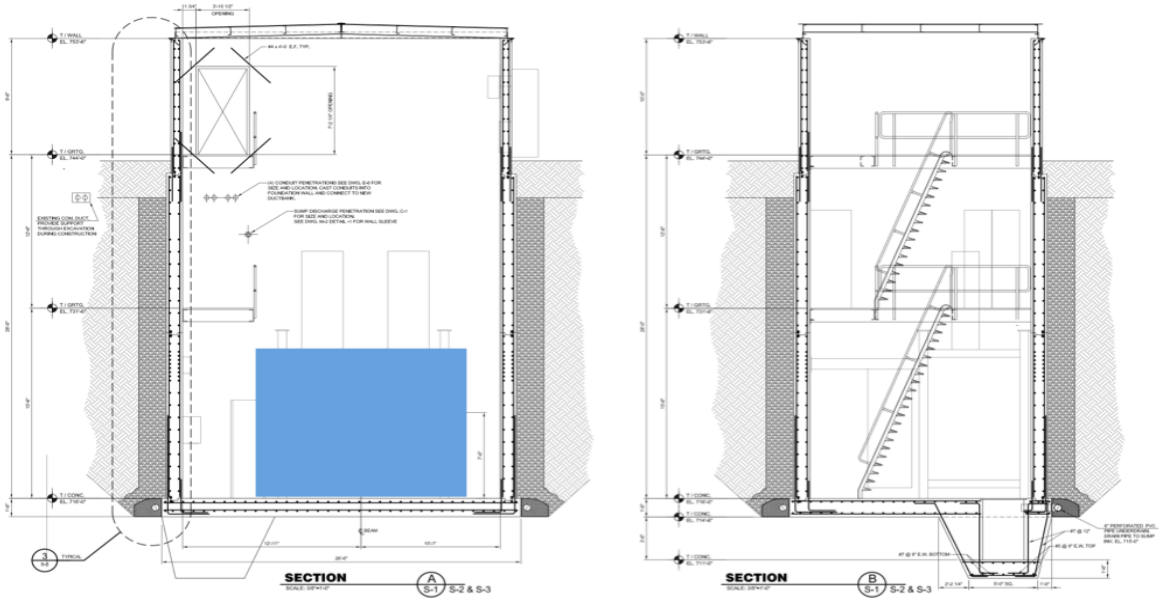

Figure 2 The position of the veto in the hall.

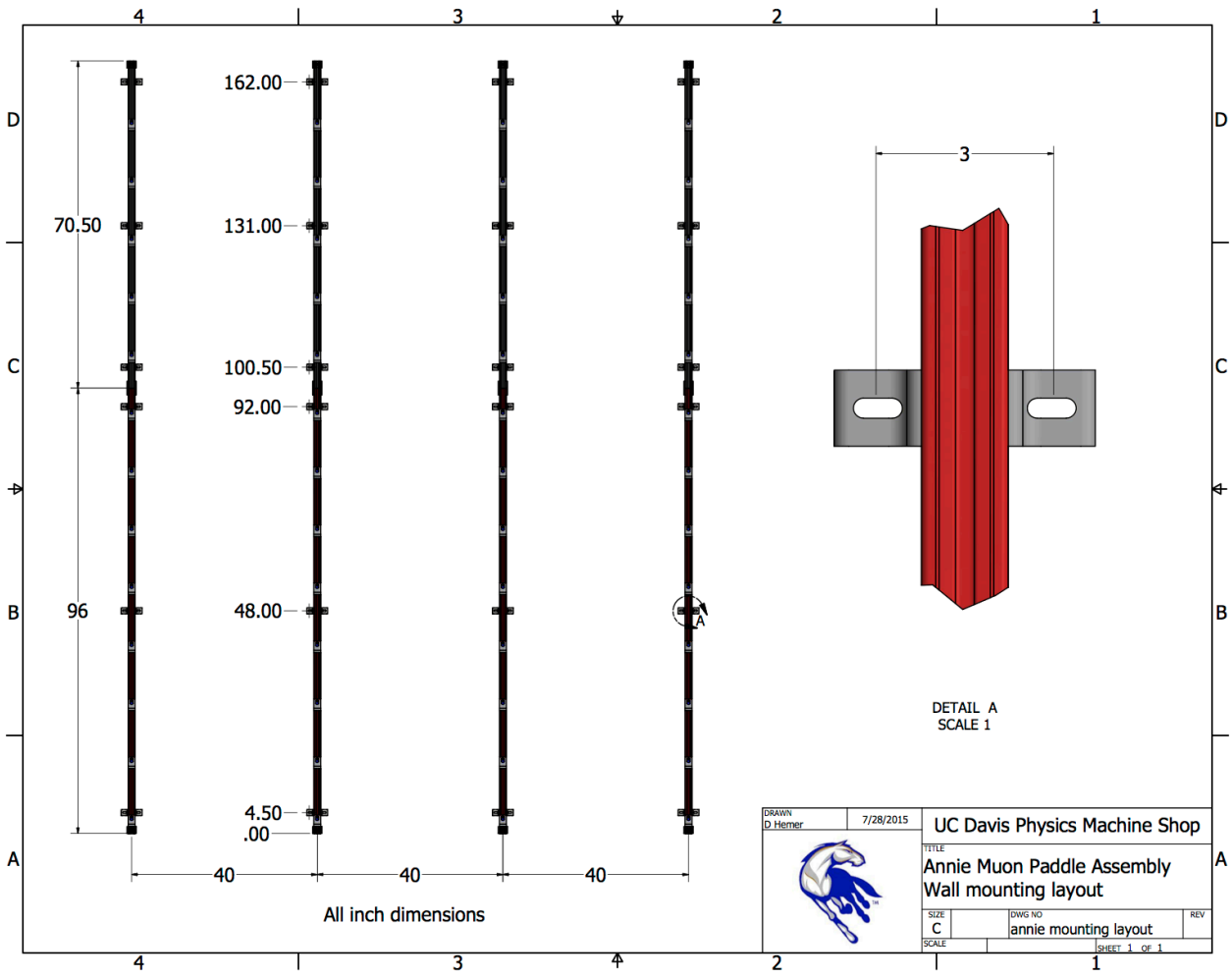

Figure 3 Hole and bracket positions in the hall.

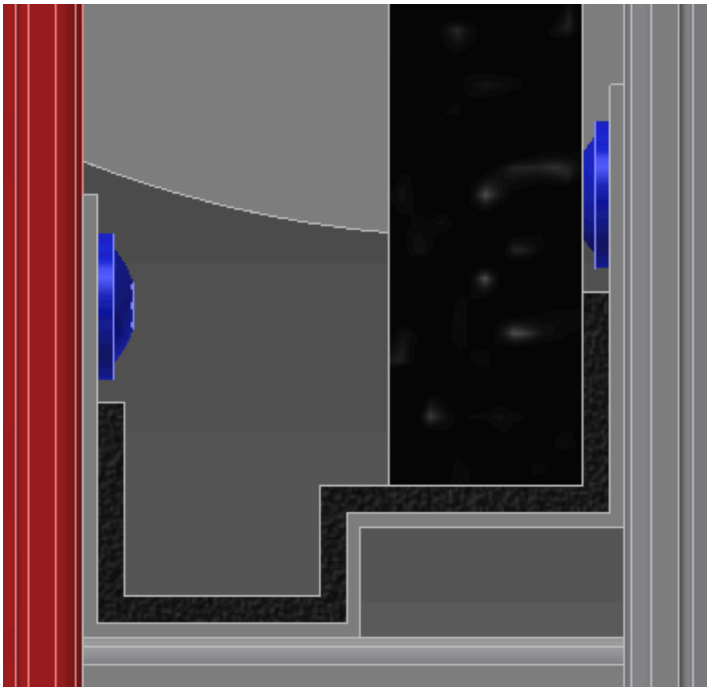

Figure 4 A side view of the bottom custom shaped aluminum strap (with only one paddle installed).

Figure 5 An example of the Faztek material to be used for the struts.

Step by Step Assembly Procedure:

1. Remove horizontal conduit near floor on front wall. Relocate to second level height (above 14 feet from floor)
2. Install moly bolts in the following pattern: See Figure 3

3. Bolt vertical rails bottom section using 90 degree brackets.
4. Using a ladder, bolt the smaller top section of the vertical brackets.
5. Slide all needed t-slot brackets into vertical rails from top
6. Install “foot” section on bottom of each rail
7. Install slat on each rail with required spacers (see figure 4)
8. Drop in both paddles and spacers
9. Connect HV and signal cable to the paddles. Power up to the set operating voltage and measure dark noise rate (should be <2 KHz) and note pulse height (should be 10-20 mV). If necessary, fix any light leaks
10. Power down the paddle and move to next layer. For every layer, test the paddle and repair as necessary.
11. After completing first three layers, install the outer retaining strut and bolt in place. Continue on to next layer.
12. After reaching over five feet (5^{th} layer) stop and install scaffolding for next five layers.
13. Install layers 6-10, putting in retaining strut every three layers
14. Install scaffolding for last three layers (11-13)
15. Install layer 11-12 and add retaining strut.
16. Install 13^{th} layer and short retaining struts.
17. Install capstone short strut on top (as shape as foot on floor)
18. Route cables to electronics rack on second level. Make a final test of all paddles
19. Remove scaffolding